

Face Recognition and Gender Classification
using
Principal Component Analysis

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May 2014

Face Recognition and Gender Classification using Principal Component Analysis

Dissertation submitted in

May 2014

to the department of

Computer Science and Engineering

of

National Institute of Technology Rourkela

in partial fulfillment of the requirements

for the degree of

Master of Technology

by

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*dedicated to my Parents, brothers, sisters and all my
lovely freinds...*



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Certificate

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Acknowledgement

I am thankful to various nearby and worldwide associates who have helped towards molding this thesis. At the beginning, I might want to express my true thanks to Dr. Pankaj Kumar Sa for his recommendation throughout my thesis work. As my supervisor, he has always swayed me to stay concentrated on accomplishing my objective. His perceptions and remarks helped me to build the general bearing of the research and to push ahead with research in profundity. He has helped me significantly and been a source of information.

I am really obligated to Dr. S.K Rath, Head-CSE, for his continuous encouragement and support. He is always ready to help with a smile. I am also thankful to all the professors of the department for their support.

I am also grateful to *Prof. Banshidhar Majhi* for his ceaseless support throughout my research work.

It is indeed a privilege to be associated with people like *Prof. S.K.Jena, Prof. D. P. Mohapatra, Prof. A. K. Turuk, Prof. S.Chinara, Prof. Ratnakar Dash* and *Prof. B. D. Sahoo*. They have made available their support in a number of ways.

My true thanks to my all friends and to everyone who has provided me with kind words, a welcome ear, new plans, valuable feedback, or their invaluable time, I am truly indebted.

Last, but not the least, I would like to dedicate this thesis to my family, for their love, patience, and understanding.

Vijay Kumar Sarthi

Abstract

Face recognition is one of the most challenging areas in the field of computer vision. In this thesis, a photometric (view based) approach is used for face recognition and gender classification. There exist several algorithms to extract features such as Principal Component Analysis (PCA), Fisher Linear Discriminate Analysis (FLDA), Image principal component analysis (IPCA), and various others. Principal component analysis is used for the dimensional reduction and for the feature extraction. Two face databases are taken in which one database contains the face images of male and one contains face images of females. On the basis of Euclidean Distance classification of the gender is done. Comparison between Euclidean Distance and Mahalanobis Distance for face recognition is also done with different number of test images. This method is tested on FERET and IIT Kanpur's database.

Keywords: Face recognition, PCA, FERET database, Photometric, Euclidean Distance.

Contents

Certificate	iii
Declaration	iv
Acknowledgment	v
Abstract	vi
List of Figures	ix
1 Introduction	2
1.1 Face recognition techniques	3
1.2 The main uses of Face recognition	4
1.3 Face recognition steps	7
1.4 Applications	7
1.5 Motivation	8
1.6 Challenges	9
1.7 Advantages of face recognition system	9
1.8 Disadvantages of face recognition system	10
1.9 Objectives	10
1.10 Feature Extraction Methods	10
1.11 Principal Component Analysis	10
1.11.1 Method of PCA	11
1.11.2 PCA in face recognition	11
1.11.3 Mahalanobis Distance	13

1.11.4 Euclidean Distance	13
2 Literature Review	15
3 PCA for Face Recognition and Gender Classification	24
3.1 The main Steps for the implementation	26
3.2 Results	30
4 Conclusion and Future Work	37
Bibliography	38

List of Figures

1.1	Face recognition task	4
1.2	Face recognition system for identification	5
1.3	Face recognition system for verification	6
1.4	Face recognition process	8
3.1	A colored face image	25
3.2	A gray scale face image	26
3.3	A single person's image with 10 different pose	27
3.4	A male database image	28
3.5	A mean image of database images	29
3.6	Eigen face image of the selected images	30
3.7	Face image database for male	31
3.8	Face image database for female	32
3.9	A recognized image for a test image	32
3.10	A test image input	33
3.11	A figure for gender classification	33
3.12	Euclidean distance for male database	34
3.13	Euclidean distance for female database	34
3.14	Euclidean distance for both the database	35
3.15	Comparison between Euclidean distance and Mahalanobis distance	35

Chapter 1

Introduction

Chapter 1

Introduction

A face recognition system is one of the popular Computer Application for automatic verification or identification of any person either from a given image or from any video source. Face recognition is mainly used for the security purpose and one can compare this with the other biometrics like fingerprint, iris recognition system. The main advantages of a face recognition system over the other biometrics application is that it not necessary need to ask the person to come in front of camera or in any sensor like in other it required the person should take his body in front of the sensor and stay there for few second. For the face recognition if a person is simply walking from any surveillance camera it can capture information of the person without his/her knowing about that and can identify or verify the person. In a face recognition problem we are simply giving an input image and the facial database of the person known individuals and it identify or verify the given image. There are basically two approaches for the face recognition: geometrics (feature based) and photometric (view based). In the geometrics we need to select only some distinctive features like nose, eyes, mouth and measure the geometric relationship among these facial points. The mostly used algorithm for face recognition is Principal Component Analysis (PCA) is example of photometric based approach.

Face recognition steps: The face recognition is mainly done by performing the following process: 1. Image acquisition: This is the very first step for the face

recognition in this required to acquisition of any image either by camera or by any other source. 2. Image Preprocessing: Some preprocessing is required to perform before using the acquired image for the recognition. 3. Face detection: After doing the preprocessing now it required to detect the face from the given image. Since for performing the face recognition we basically need a face of any person. So the face detection is done before performing the face recognition. 4. Feature extraction: The next step after face detection is extracting the important features of the face which can be used for comparing with the image database of individuals. 5. Declaring a match: After performing the above steps it required to identify or verify the given image from the database. In this we can classify any given image in face or non-face or in any other groups according to the requirement. the face recognition is mainly used for the verification and identification and it can be shown by the fig 1.1.

1.1 Face recognition techniques

- Traditional: There are some algorithms which extract the facial features or landmarks from an image for example the position of nose, eyes, jaw and cheekbones. After extracting these features, then it is used for the matching the similar features in the image database.
- 3-dimensional recognition: Now days the 3-dimensional recognition technique is very popular and mostly used for the face recognition. Other techniques are not that much more accurate in the different lighting and in non-frontal view, but in 3-D recognition there is no effect of changes in lighting. In this technique, it required a 3-D sensor for getting the information about the face surface. Then this information is used for identifying or verification of any person.
- Skin texture analysis: The visual details of the skin are used in this technique which are captured in standards digital image or scanned image. This skin texture analysis improves the performance on the recognizing the face.

1.2 The main uses of Face recognition

The face recognition is mainly used for the two purpose, identification and varification. means by using the face recognition system a person's identification or verification can be automatically done.

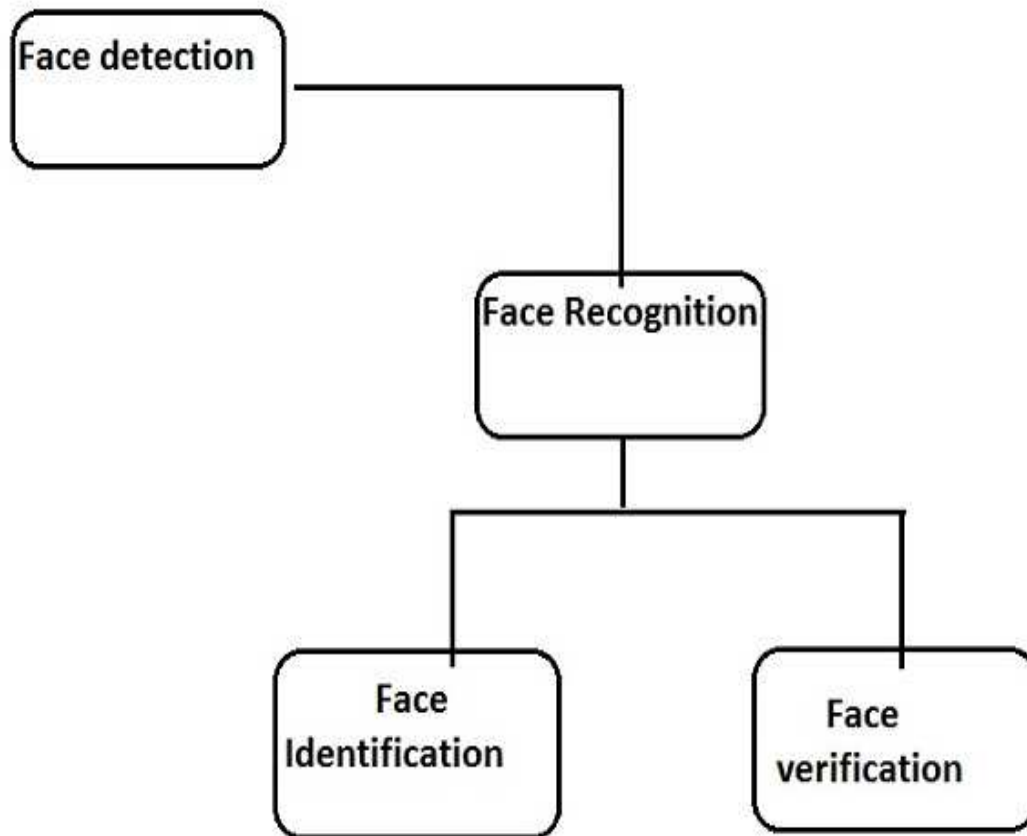


Figure 1.1: Face recognition task

- Identification: In the identification a face recognition system takes an input image and compared it with all the other images in the database and in result it gives the rank wise list of the matched image. In the identification one image is compared with all the images in the database and the image which will be similar to the input image will be the output. identification can be explained by the fig 1.2

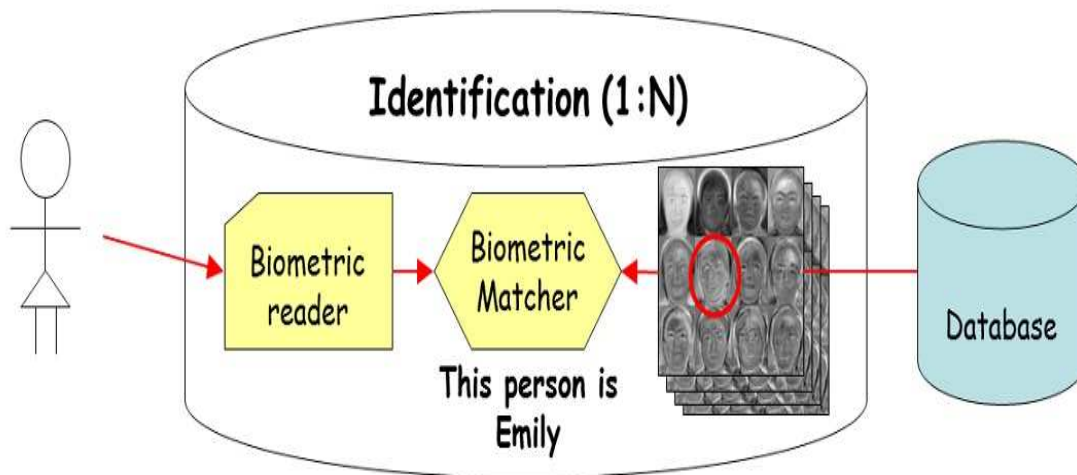


Figure 1.2: Face recognition system for identification

- Verification: In the verification a face recognition system takes an input image and claim of identity and compared it with who they say they are and it give the answer yes or no. In verification one to one comparison is done by the system means the input image is compared with already specify an image in the database and if it will match it will give a yes answer otherwise it will give no answer.verification can be explained by the fig 1.3

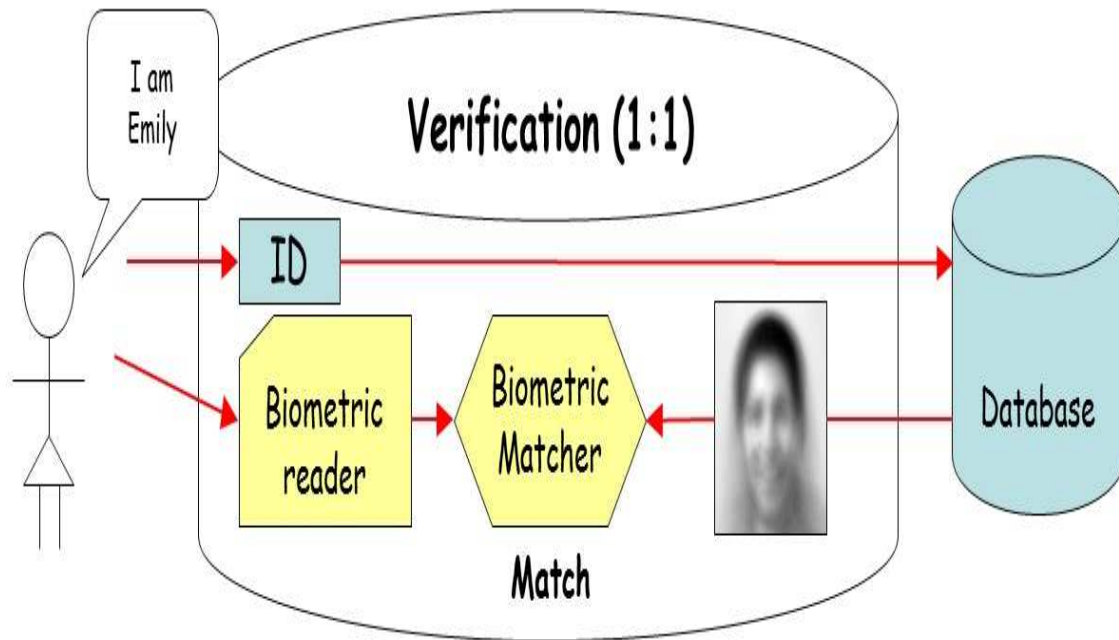


Figure 1.3: Face recognition system for verification

1.3 Face recognition steps

The face recognition is mainly done by performing the following process:

1. Image acquisition: This is the very first step for the face recognition in this required for acquisition of any image either by camera or by any other source.
2. Image Preprocessing: Some preprocessing is required to perform before using the acquired image for the recognition.
3. Face detection: After doing the preprocessing now it required to detect the face of the given image. Since for performing the face recognition we basically need a face of any person. So the face detection is done before performing the face recognition.
4. Feature extraction: The next step after face detection is extracting the important features of the face, which can be used for comparing with the image database of individuals.
5. Declaring a match: After performing the above steps it required to identify or verify the given image from the database. In this we can classify any given image in face or non-face or in any other groups according to the requirement. the steps for face recognition can be shown by the fig 1.4

1.4 Applications

The face recognition can be used in several areas, but it is basically used for the security purpose and some other areas where face recognition can use are as follows:

1. Security: If anyone wants to give the access control to only specific person then he/she can apply the face recognition there. For example, wants to give access to airport, buildings, ATM machine.
2. Surveillance: Now day, lots of surveillance cameras are used for monitoring any known criminal if anyone passes through that camera he/she can easily identify.
3. General identity verification: Face recognition can be used for verifying the

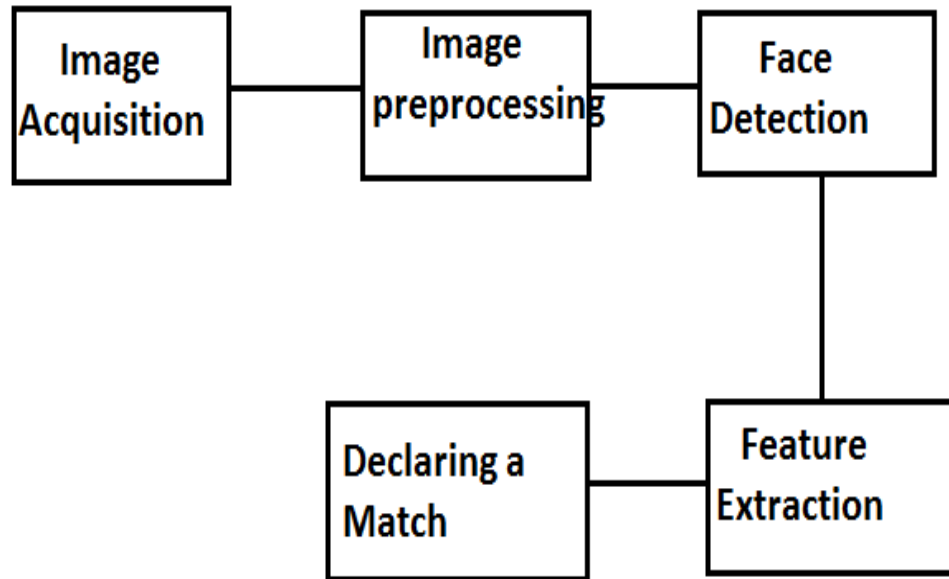


Figure 1.4: Face recognition process

identity of any person. For example voter ID, driving license, employee ID etc.

4. Video indexing: The face recognition can also use in the area of video indexing such as abeling faces in video.

5. Criminal justice systems: The face recognition can be used in the field of Criminal justice System such as mug-shot/booking systems, post-event analysis, forensics etc.

1.5 Motivation

The face recognition can be applied in several areas, although face recognition is not the most efficient among other biometrics. The main advantage of the face recognition over the other biometric application is that it's not necessarily need

to ask the person to come in front of camera or in any sensor like in others, it required the person should take his body in front of the sensor and stay there for a few second. Face recognition can be used in so many areas like security, criminal justice systems and video indexing etc. There is no system which can give better results in Variations in lighting conditions, pose, and expression. It is difficult and challenging task to make a system which will perform well in different pose and variations in lighting. The most important thing required for the face recognition is robustness and reliability.

1.6 Challenges

A person is identified by the process of face classification and face recognition by his facial image. In the following condition face recognition systems are not able to perform well:

1. Illumination variation
2. Change in the expression
3. Change in Camera angle
4. Head pose
5. Growth of facial hair due to age or duplicated hair attached to fool the system.

1.7 Advantages of face recognition system

1. It is helpful for finding any missing children.
2. It can identify any criminals, terrorists, etc.
3. It can prevent from the voter fraud.
4. For the identification of any individual there is no need to make direct contact with an individual in order to verify their identity. Unlike in other system (fingerprints, Voiceprint, signature).
5. Other biometrics such as fingerprints, iris scans, and speech recognition are not able to perform mass identification.

1.8 Disadvantages of face recognition system

1. Face recognition systems are not able to perform well in the variation of illumination.
2. Face recognition systems are not always accurate.
3. In poor lighting, sunglasses, long hair, low resolution image face recognition does not work well.

1.9 Objectives

Face recognition is not perfect and struggles to perform under certain conditions. Like in poor lighting, low resolution etc. So objective is to design a better and robust face recognition system and a system which classifies the gender from a given image.

1.10 Feature Extraction Methods

There are so many existing algorithms are available to extract features from any facial images such as Principal Component Analysis (PCA), Fisher Linear Discriminate Analysis (FLDA), linear discriminant analysis (LDA), Image principal component analysis (IPCA) and various others. Here we have used principal components analysis.

1.11 Principal Component Analysis

Principal Component Analysis is a statistical and mathematical technique and it is mainly useful in face recognition and image compression. Identification of patterns in data and expressing the data in such a way that highlights the difference and similarities between the data is done by the principal components analysis. Since it is a very difficult task to find the patterns in data in the data of high dimension the main objective of the principal components analysis is to reduce the dimensionality

of the given data and it can also use for the data compression. The largest dimension of the data space has reduced into the smaller natural dimension of the feature vector is the main purpose of the principal components analysis. Which describe the data cost effectively. In principal components analysis the main advantage is when eigenface approach is used it to reduce the size of the database which is required for the recognition of any test image. These eigenfaces are selected from the eigen vectors means eigenfaces are set of the eigenvectors which are used in computer vision problem for face recognition. This approach is used by Matthew Turk and Alex Pentland for face recognition and classification. These eigenvectors are calculated from the covariance matrix of the training database of the high-dimensional vector space.

1.11.1 Method of PCA

Step 1: The first step for the PCA is to get the data set.

Step 2: The next step of PCA is to calculate the mean of a given data set.

Step 3: The next step is to subtract the mean with each data of the data set, Then this produces a data set whose mean is zero.

Step 4: Then calculate the covariance of the matrix. If the data are two dimensional, then the covariance matrix will be of 2×2 and if the data is of N dimensional the covariance matrix will be of $N \times N$.

Step 5: The next step is to calculate the eigenvalues and eigenvectors of the covariance matrix.

Step 6: The last step of PCA is to select the components and forming a feature vector.

1.11.2 PCA in face recognition

When we want to apply the PCA in face recognition first things that we need is the face images which are generally in two dimensions. Suppose the image is of $N \times N$. Here our main objective of applying the principal components analysis is to reduce the high dimensional training set into the lower dimensional space by

finding the Eigen faces also known as principal components. The first task for this is to represent the image into the vector form so we need to reshape the image from $N \times N$ to $N^2 \times 1$. Let suppose the total number of images in the training set is M. Let this form of image in training set be represented by L_M .

Steps for Computation of the Principal components:

Step 1: We have a training database of face vectors so the first task is to calculate the mean of that faces vectors. Let the mean is μ .

Step 2: Next step is to subtract the mean from all the image vectors L_M .

Step 3: Next we compute the covariance matrix C which is of $N \times N^2$ matrix.

Where $D = [L_1, L_2, L_3, \dots, L_M]^T$ ($N^2 \times M$ matrix)

Step 4: Next step is to find the eigenvalues and eigenvectors of the matrix C or DD^T . Let the eigenvectors of the covariance matrix is u_i . But DD^T is very large dimensions ($N^2 \times N^2$) as we can see so practically it is not possible to compute the eigenvectors of this size. So instead of finding the eigenvectors of this matrix we can calculate the eigenvectors from the matrix $D^T D$ which is of size $M \times M$. Let v_i is the eigenvectors for this $D^T D$. So $D^T D v_i = s_i v_i$

Where s_i is an eigenvalues So the relationship between u_i and v_i is

$$D^T D v_i = s_i v_i$$

$$\implies D D^T D v_i = s_i D v_i$$

$$\implies C D v_i = s_i D v_i$$

$$\implies C u_i = s_i D u_i$$

It means u_i is equals to $D v_i$ So the DD^T and $D^T D$ have the same eigenvalues, But there eigenvectors are different and they are related by $u_i = D v_i$.

Step 5: After computing the eigenvectors we need to select the K eigenvectors whose eigenvalues are larger.

Step 6: So now we have the K best eigenvectors this K selected eigenvectors are used for representing the whole database.

Step 7: For recognition of any unknown face image we first need to convert the given image into the linear form, then it need to subtract the mean (μ) which were calculated earlier.

Step 8: Next we need to project this on all the selected components. Then we need

to calculate the distance either by using the Euclidean distance or by Mahalanobis distance and the calculated distance which is minimized is the equivalent image of the given input image. We can give a threshold value and if the distance is more than value according to that we can identify that given image is of any facial image or not.

1.11.3 Mahalanobis Distance

To find the Mahalanobis distance in the plane, between any two points is calculated by the following formula: Let $a = (a_1, a_2)$ and $b = (b_1, b_2)$ then the distance between a and b is

$$D(a,b) = ((a - b)^T S^{-1} (a - b))^{1/2}$$

1.11.4 Euclidean Distance

To find the Euclidean distance in the Euclidean plane, between any two points is calculated by the following formula: Let $a = (a_1, a_2)$ and $b = (b_1, b_2)$ then the distance between a and b is

$$D(a,b) = ((a_1 - b_1)^2 + (a_2 - b_2)^2)^{1/2}$$

Chapter 2

Literature Review

Chapter 2

Literature Review

- Face Recognition using Eigen-faces, Fisher-faces and Neural Networks:
Sahoolizadeh et al. [1] proposed a new face recognition method which is based on the PCA (principal component analysis), LDA (linear discriminant analysis) and NN (neural networks) and in this method of face recognition there are four steps: 1) In first step the preprocessing is done in this all the image of the database are first cut manually to 40×40 images so the background information can remove and have only face details, 2) After the preprocessing next step is reduction of the dimension, They used principal component analysis for the reduction of dimension, 3) For the feature extraction they used the linear discriminant analysis, 4) After feature extraction the last step is to do the classification by using the neural network and when few number of sample images are available the combination of PCA and LDA improves the capability of LDA, and the use of neural network classifier reduce the number of misclassification and after using the PCA for feature extraction and dimension reduction we need to select the fisher faces based on the nonzero eigenvector and after that they for the classification of the input data they have used a three layers perceptron neural network in which there is 40 neurons in the input layer, and 20 layers in the hidden layer are used and in the last layer (output layer) 10 neurons have used and according to the desired values for the updates of weights a simple

back propagation algorithms are used and by using LDA features the three layers MLP neural network is trained and Training LDA features enter the neural network and according to their class, a back propagation error, spread on the network and correct the weights toward the right values and this new proposed method for efficient face classification is getting a very high recognition rate which is equals to more than 99 percentage. the simulation used the YALE face datasets and this new method for the face recognition can used for the many applications such as security applications.

- Face Recognition using Principal Component Analysis:

Kim et al. [2] proposed a face recognition method in which they have used the principal component analysis for the dimension reduction and for the feature extraction. In this the two dimensional facial images express into the large one dimensional vector form and main idea of this is to express this one dimensional vector into a compact principal component of feature space. This is also known as eigenspace projection. In this paper they have reshaped the 2-D image of $N \times N$ into a $N^2 \times 1$. And they have taken the ORL database for the simulation and instead of storing all images from the database they have calculated the mean of this databases image and subtract this with all the 1-D $N^2 \times 1$ images. After subtraction they got the images with unique feature, then they have calculated the eigenvalues and the eigenvectors of the covariance matrix. On the basis of the eigenvalues some eigenvectors are selected as a principal component. After selecting the eigenfaces they have calculated the Euclidean distance. They were considered in the face identification. They have classified the face into the non-face or unknown faces and that the given face is there in the database or not. As all images is highly correlated with itself. And the first eigenface can be used as a filter. The image with low correlation can be rejected or we can say it can be classified into a non-face category. They have selected a threshold on the basis of that they have given the following conclusion: 1. Near face space and near stored face \implies known faces.

2. Near face space, but not near a known face \implies unknown faces.
 3. Distance from face space and near a face class \implies non-faces.
 4. Distance from face space and not near a known class \implies non-faces. [2]
- Classification of Face Images Based on Gender using Dimensionality Reduction Techniques and SVM:
Mannan et al. [3] In this paper they have present a new technique for the gender classification of any face images. In this they have used the dimensionality reduction techniques like Independent component analysis (ICA) and principal component analysis (PCA) along with Support vector machine (SVM). Here they have taken two databases, one for training and one for the testing. And they have done the experiments by varying the size of the database. With the different numbers of the images its performance is varying. The change in pose and illumination is the major challenge for the gender classification so here only the frontal view is taken for the experiments. Generally the gender classification requires features extraction from the images, and the finally the training classifiers performing the classification of the new faces by using that feature. The extracted features are used for the SVM classifier and then the images in the test database are classified by using the classifier. For the minimization of the classification error a maximal separating hyperplane are constructed by the SVM between two classes. In this they have mapped the linearly non-separable data input to the high dimensional feature space where they can be separated by a hyperplane. In this work they have done the gender classification by using the PCA and ICA along with SVM with the different numbers of images in the data set. And the performance also varied for different datasets. In their works the accuracy was varied according to the use of ICA and PCA. Overall the accuracy is more than 85 percentage.
 - Face Recognition Using Kernel Eigenfaces:
Yang et al. [4] In this they have improved the some drawback of the principal component analysis, such as the PCA is very useful for the dimension

reduction, but it is only for the second order statistics of any image and it does not work for the higher order statistics (HOS) dependencies. Higher order statistics (HOS) dependencies means the relationships among the three or more pixels. They have investigated a generalization of PCA. The higher order statistics are computed by the kernel principal component analysis without explosion of time and memory complexity. Generally PCA finds the correlation of the second order of patterns, but in this they have done by the kernel principal component analysis which takes higher order correlation. They got the result with this method which is improved from the PCA. They have used two image databases for the test of this new method the AT and T database and Yale database. The AT and T database is contained of the 400 frontal face images. In 400 images 40 subjects of a different pose and variation in facial expression is there. And it also tested for the Yale database which contained 165 images of 11 subjects. In the PCA each pattern can be reconstructed by using all the Eigen vectors and the principal components. But in this experiment they got there is no direct counterparts in kernel principal component analysis like in the PCA. As the image set of the Eigen face approaches is second order statistics and not used higher order statistics, dependencies like the relationship among three or more pixels. They have tested on the two datasets they investigated that kernel PCA provides an effective representation for face recognition. And they have compared their results with other techniques it gives better results and the error rate is also less.

- Two-dimensional PCA, A New Approach to Appearance-Based Face Representation and Recognition:

Yang et al. [5] In this they have proposed a new technique for the face recognition which is somehow related to the principal component analysis, but the only difference is it used two dimensional PCA. In this new technique they used 2-dimension image matrices for the feature extraction not like the PCA. In the PCA it needs to transfer the 2D image into the 1D vectors

form before extracting the features. In 2DPCA (two dimensional principal component analysis) an image covariance matrix is directly constructed by using the original image matrices and the eigenvectors are also derived directly from the original image matrices for the feature extraction. In this new method they first multiply the 2-D matrix by a unitary matrix so the image matrices will become in the linear form and then calculate the eigenvectors of the covariance matrix. They have tested this new technique with three different face image databases such as ORL, AR and Yale. The ORL database which has the images with the various pose and variation in the sample is used for the evaluation of the performance of the two dimensional PCA. And the AR database is used for evaluating the performance of the 2DPCA in the facial expression and change in lighting condition over a time. And they got from the experiments that the 2DPCA is computationally more efficient than the PCA in the extraction of image features. In this experiment they compare with the PCA and the recognition accuracy is improved in the two-dimensional principal component analysis.

- Eigenfaces vs. Fisherfaces: Recognition Using Class Specific Linear Projection:

Belhumeur et al. [6] In this they have developed a new algorithm for the face recognition which is not bothered about the large variation in the lighting direction and also no problem if there is variation in facial expression. Means they have proposed an algorithm which is Insensitive in various changes in the facial images. They have used a pattern classification approach in this and they have taken the each pixel of the images as a coordinate in a high dimensional space. The images of any face under varying illumination, but no change in facial pose, lie in 3D linear subspace of the high dimensional image space. So they took it as an advantage. In this they linearly projected the image into a subspace in such a manner that discounts the regions of the face which has the large deviation. This method of the projection is mainly based on the Fishers linear discriminant and this method produced

well separated class in a low-dimensional subspace. They have tested this method with the Harvard and Yale face databases and they have got from the experiment that the Fisherface method has a lower error rate as compared to the eigenface techniques.

- Face Recognition Using Laplacianfaces:

He et al. [7] They proposed a new approach called Laplacianfaces is an appearance based method for the face recognition. In this new method they have used Locality Preserving Projections (LPP) and in this the face images are mapped into the face subspace for analysis not like in principal component analysis (PCA) and linear discriminant analysis which see the Euclidean structure of face space. In this proposed method the LPP finds an implantation that preserves the local information, and LPP acquires a face subspace that best detects the necessary face manifold structure. Linear approximations to the eigenfunctions of the Laplace Beltrami operator is applied to the face manifold. And the optimal is selected as a Laplacianfaces. When there is change in lighting, facial expression and pose the result of recognition can vary, but by using this new approach they have reduced the unwanted change in the result. It increases the accuracy of the recognition. This approach is tested for the three different databases and they compared it with the others techniques like PCA and they got that the LPP can have more discriminating power. This proposed Laplacianfaces approach is achieved lower error rates and provides better results for the face recognition.

- Face Recognition Using LDA Based Algorithms:

Lu et al. [8] Low-dimensional characteristic representation with improved discriminatory power is of fundamental importance to face recognition (FR) frameworks. The greater part of conventional linear discriminant analysis (LDA) based techniques experience the ill effects of the impediment that their optimality criteria are not specifically identified with the classification capability of the acquired characteristic representation. In addition, their

arrangement precision is influenced by the "small sample size" (SSS) issue which is regularly experienced in FR task. They have proposed another calculation that arrangement with both of the weaknesses in an efficient and financially effective way. The proposed here strategy is compared, as far as classification accuracy, to other usually utilized FR routines on two face databases. Results demonstrate that the execution of the proposed system is general better than those of conventional FR methodologies, for example, the Eigenfaces, Fisherfaces and D-LDA methods. In this they have used two popular face databases, UMIST and the ORL database to demonstrate the effectiveness of their proposed methods. The ORL database contains 40 subjects with 10 different images per subjects.

- A direct LDA algorithm for high-dimensional data with application to face recognition:

Yu et al. [9] In many classification problems such as face recognition, speech recognition, the linear discriminant analysis (LDA) has been used for the reduction of the dimensions. But there is a problem in the traditional LDA algorithm. A face image of size 64×64 that implies a feature space of 4096 dimensions and there for the scatter matrices of 4096×4096 which is very challenging for the computation. In this approach they have tried to overcome this problem. They have tested this for Direct LDA algorithms with ORL dataset which consists of around 400 frontal face images of 40 subjects with the variation in the pose, illumination and changes in facial expressions. In this they have randomly chosen 5 images per persons for the training set and they directly apply the LDA without dimension reduction and they get average recognition accuracy is more than 90 percentage. In this new approach gives better result and the error rate is less.

- Face Recognition Based on Frontal Views Generated from Non-Frontal Images:

Blanz et al. [10] In this they have proposed a new technique for the face recognition towards the large changes in viewpoint. Most of methods are

not able to give a good result if the input image is non-frontal view but, this method can take a non-frontal image as an input and first it change the input image into frontal view. This method is based on a Morphable Model of 3D faces that represents the information about the face which is extracted from 3D scans. This method of face recognition is take place in two steps in the first step a 2D still image is apply into a Morphable model means the preprocessing is done and an estimated 3D shape of the novel face is constructed from the non-frontal image. And it generates a frontal view of the reconstructed face. It is done by using the standards illumination in 3D computer graphics. After that they have fed this frontal image into any face recognition system that is optimized for frontal views. After getting they tested this approach for the Coefficient-based recognition and also for the viewpoint-transformed recognition. In the view based transformation there is a frontal view image gallery and one input image is in non-frontal view, they first change this input image into frontal view by placing the face of the input image in already scan 3D images then by using the computer graphics they perform the rotation and transformation for getting the frontal view of image. This method is very effective and it is tested with the FRVT 2002. In this process the 3D shape of the face image a set of coefficients are also estimated. In the second method directly from these coefficients face recognition is done. They compared the result with the image in FRVT 2002 and the results to recognition from model coefficients.

Chapter 3

PCA for Face Recognition and Gender Classification

Chapter 3

PCA for Face Recognition and Gender Classification

We have used MATLAB 2012 for the implementations of face recognition and for the gender classification. In this work we are taking two face image databases and one test database which contained face image for the testing of the system. In this we are giving a test image as input and we have to identify an input image and classify it into a category of male or female. In fig 3.1 We have taken a color image and we are converting it into a gray scale image, because we can easily apply the computational techniques when the image is a gray scale image as compared to color images.



Figure 3.1: A colored face image

A colored image from the database is converted to the gray scale image as shown in fig 3.2 and it should be of the same size for applying the Principal component analysis. In this we have taken a database from the IIT Kanpur which contains the image of males and female separately. In the all subjects have 10 different images with different pose, and change in expression. When any persons change his/her expression then the feature vectors accordingly change with that and the change in illumination may change the recognition rate. And it depends on the size of the image also it varied accordingly the change in size. As in fig 3.3 shown a single person's image with different expressions. Our objective is to



Figure 3.2: A gray scale face image

make a system which can recognize an input image and can classify it into a male or female category. For this we are using principal component analysis to reduce the high dimensional space into the lower dimension.

3.1 The main Steps for the implementation

We have followed following steps for implementing it:

Step 1: Created training Image database for male and female separately and load



Figure 3.3: A single person's image with 10 different pose

it. A database is created for a set of images in different condition with the 10 different expressions, pose and illumination for the 10 different persons separately for male and female. A database for male is shown in the fig 3.4

Step 2: After creating the database the second task is to convert face images in the training set to face vectors. We have taken images of size 70×70 , now we have reshaped the database image into 4900×1 image. So now all the images of the database are in vector form.

Step 3: After getting the images in vector form, we normalize the face vectors by calculating the mean of both the database male and female. Mean face is obtained by:

$$m = \sum(A_i + B_i)/(M + N).$$

Where i is a index number of images in the database and M and N is the total number of images in the male and female database. After calculating the mean image we subtracted the mean face with all the images in the both databases. After calculating the mean the image of mean is looks like the fig shown in 3.5.



Figure 3.4: A male database image

Step 4: After calculating the mean face the next task we have done is to reduce the dimensionality of the database. Dimensionality reduction is done by calculating the covariance matrix of the face space in the $A^T A$ instead of calculating AA^T . There are 100 images in each database of male and female so face space A is of 4900×100 . And A^T is of 100×4900 so covariance matrix will be of 4900×4900 , which is practically very difficult to calculate so instead of calculating this we calculated $A^T A$ which is of size 100×100 .

Step 5: After that we have calculated the eigenvalues and eigenvectors of the covariance matrices of both the database.

Step 6: After calculating the eigenvalues and eigenvectors we have selected the 25 best eigenvectors with respect to the largest eigenvalues. The selected eigenvector can represent a whole database of image in both the database separately. the eigen faces image is shown in the fig 3.6

Step 7: After selecting the eigenvectors we have changed the low dimensionality image into high dimensional image space. It is simply done by this formula:
 $u_i = Av_i$

Where u_i is eigenvectors of the AA^T and v_i is the eigenvectors of $A^T A$.



Figure 3.5: A mean image of database images

Step 8: After this we have given an input image from the test database for recognizing that image and for the classification of this input image.

Step 9: After that we have projected this input image into the eigenface space and calculated the Euclidean distance.

Step 10: If the minimum Euclidean distance in the male database is less than the minimum Euclidean distance in the female database, then tests image is classified as male otherwise female.

Step 11: The image with the minimum Euclidean distance is the recognized image.



Figure 3.6: Eigen face image of the selected images

3.2 Results

We have taken two database for this face recognition and gender classification. the database is taken from the iit Kanpur's database [11]. and it is tested for the different number of images. This database consists of 10 images for each persons in different pose and variations in lighting.

After taking the database now we have calculated mean of all the database images. the resultant mean image is shown in fig 3.5.

The fig 3.9 shows the test and equivalent image in the database for any given test image. in this we have given an image as an input and the image which is similar to that image is the recognized image. here we have taken a test image of female so fig 3.10 is a test image. and the fig 3.11 shows the classification of the image. means it shows the input image is of male or female, here we have given an input image of female so its classified into the female categories. The graph for the Euclidean distance is shown in fig 3.12 in which the red bar shows the minimum Euclidean distance in male database. and the minimum Euclidean distance in female database is shown in fig 3.13. The graph for the euclidean distance for both the database is shown in fig 3.14 in which the red bar is showing



Figure 3.7: Face image database for male

the minimum euclidean distance so the test image will classify into the Female. because the minimum Euclidean distance is from female database.

We have tested this with the iit Kanpur's database [11].and the accuracy is 88 percentage for the gender classification when we have taken around 50 face images for the test in which there is 35 known and 15 unknown images is there.

After reduction of the dimension and extracting the feature of the images by using the Principal component analysis and after projecting the input image into the selected eigenvectors we can use either Euclidean Distance or Mahalanobis Distance for the classification of the input image or any other distance. So we have compared the accuracy of the algorithms when we used Euclidean distance and the Mahalanobis distance for the classification. For this we have taken 5 test images, then 10 test images and so on for the checking the accuracy. It is clear from the fig 3.15 that the accuracy of the algorithms is more when we are using the Euclidean distance for the classification as compared to the Mahalanobis distance. And the accuracy for the gender classification is more when we are taking the test image which are already in the database as compare to the unknown image.

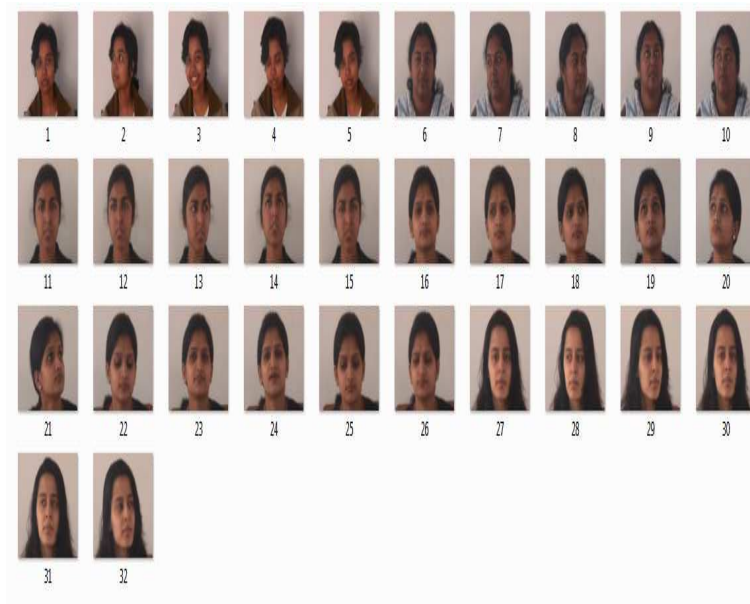


Figure 3.8: Face image database for female

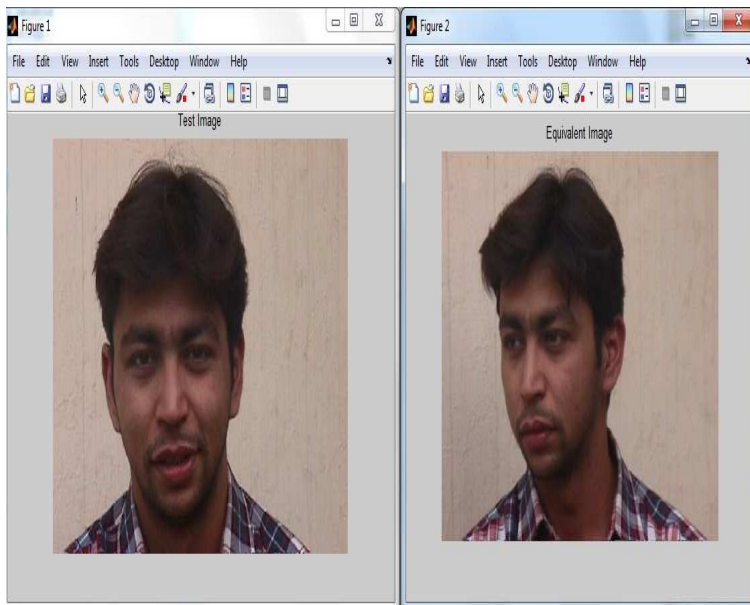


Figure 3.9: A recognized image for a test image

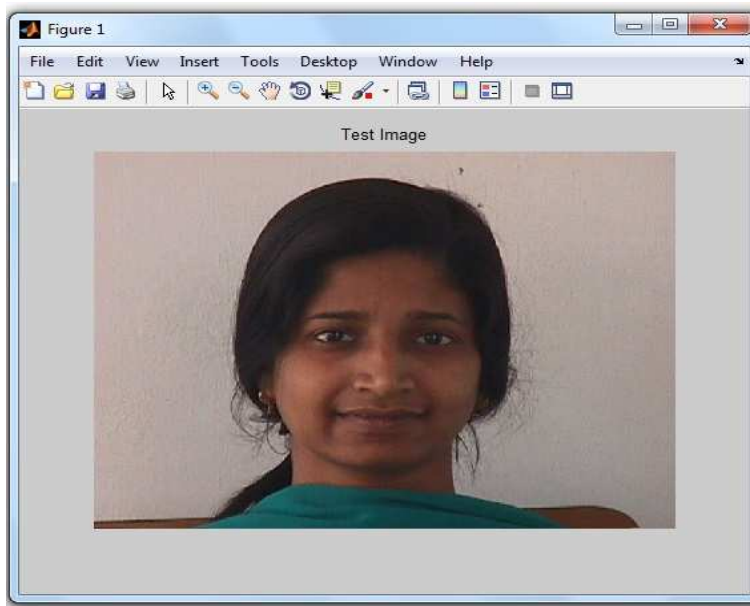


Figure 3.10: A test image input



Figure 3.11: A figure for gender classification

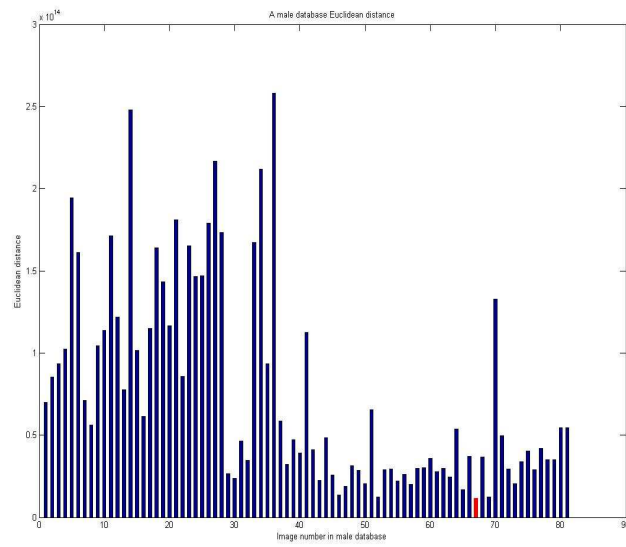


Figure 3.12: Euclidean distance for male database

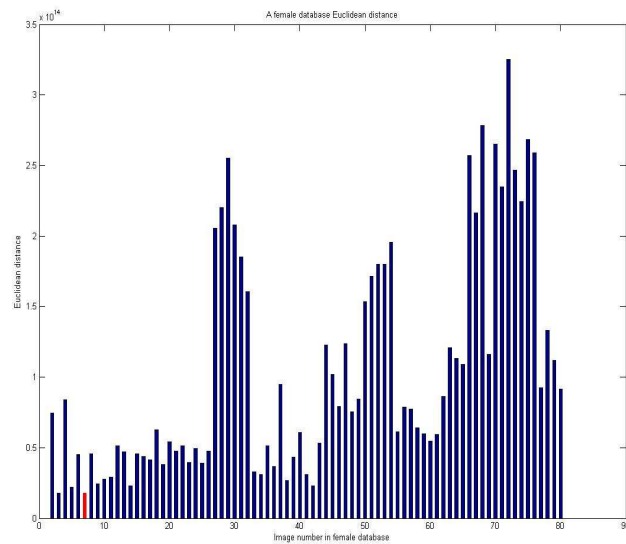


Figure 3.13: Euclidean distance for female database

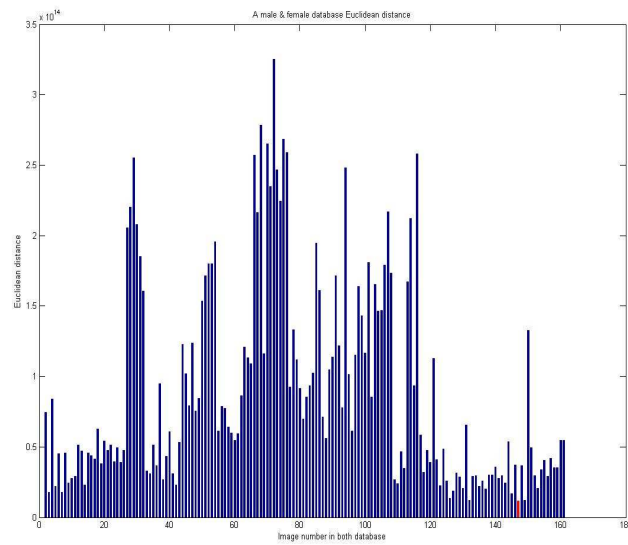


Figure 3.14: Euclidean distance for both the database

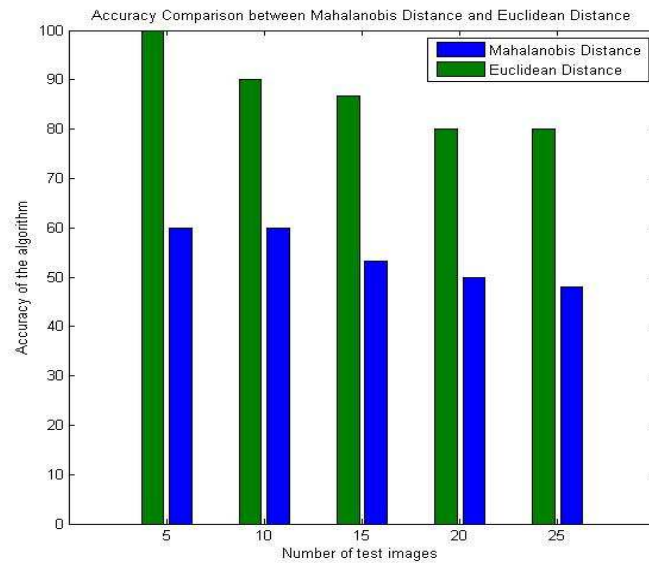


Figure 3.15: Comparison between Euclidean distance and Mahalanobis distance

Chapter 4

Conclusion and Future work

Chapter 4

Conclusion and Future Work

In this thesis we have used principal component analysis for the implementation of face recognition and gender classification system. The system is successfully recognizing the human faces and also classifying the gender of the input face image in the different illumination and variation in pose. Simplicity and high probability of getting the correct result for recognition and classification is the main advantage of using this technique. The recognition rate is varying according to the number of feature extracted from the training faces. The recognition rate also depends on lighting conditions and the clarity of the training set image and test image. The threshold should be taken carefully because threshold distance value depends for the recognition of the input image or for the classification of the input image also. When we are taking the face image which are already in the database for the testing as an input image the accuracy is high as compare to a unknown image for the gender classification.

The main drawback of using this technique is it is not able to give a more accurate result when there is change in the illumination. So we can improve it by using the geometric (feature based) approach in which we need to select only some distinctive feature like nose, eyes, and mouth and measure the geometric relationship between these facial points. So by this we can improve the accuracy rate in the future.

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